Asking too much?
Postwar climate research in Norway, 1947-1961

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Following the extremely dry summer of 1947, the head of the Norwegian Water Resources and Electricity Works, Fredrik Vogt, wrote a concerned letter to the Norwegian Academy of Science and Letters asking if the climate was changing, and if this would be possible to predict. Vogt was worried about the future stability of Norwegian hydropower: "If you can develop fairly reliable prognosis for climate variations in the coming years or decades, this would be of great practical importance for how we manage the power supply."[1] In response, the Academy established a multidisciplinary taskforce, which gave birth to an Institute for Weather and Climate Research. Parallel to this, the Meteorological Office had its own section for climate. However, by the time the Institute closed in 1960, the question of climate prediction was long forgotten.

This paper investigates Norwegian postwar climate research through studying the institution that was set up, its mandate, how the research was funded, which researchers were involved, and how they were recruited. I examine the findings, the concurrent debates on what meteorological research to conduct, and show how 'climate' held different meanings for the different actors. The goal of the paper is to explain why Vogt's request for climate prognosis was not pursued. By focusing on the overlooked period 1947-61, which was when the Institute for Weather and Climate Research operated, and before the computer at the Meteorological Office transformed the capacities of the climatologists, I demonstrate that history is not a linear affair, and that research projects that did not lead to a breakthrough are also part of it. By exploring efforts that were seen as important at the time, but did not necessarily lead to the present, we can gain better insights into how science actually works.

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[1] Letter from Fredrik Vogt, head of the Norwegian Water Resources and Electricity Works ['Norges vassdrags- og elektrisitetsvesen'], to the Norwegian Academy of Science and Letters ['Det Norske Vitenskapsakademi i Oslo'], dated Oslo, December 23, 1947. *Beretning fra utvalget for vær og klimavariasjoner, 1948 og 1949.* 1950: 2-3. [Hereafter: *Beretning.* 1950].

The drought and the committee

Although the cold winter of 1947 is well documented, particularly on the British Isles,[2] the extremely dry summer that followed in most of Europe is less well known. From the middle of July to the middle of August, the meteorologists in the Norwegian capital of Oslo registered only 2.2 millimeters of rain, compared to a 30-year average of 102 millimeters.[3] Streams and rivers dried up, there were wildfires, and electricity was rationed.[4] In September, the Norwegian School of Agriculture reported that the rainfall in the growth season had been between a fourth and a fifth of that in a normal year, and that crop yields were halved.[5] Farmers were instructed to butcher farm animals to save on food supplies for the coming winter, and in a country still rebuilding after five years of Nazi occupation, newspaper columnists commented: "This is a crop failure of the worst kind; a catastrophe no one had believed could befall Norwegian agriculture in our time."[6]

The consequence of the drought on the production of hydroelectric power was especially alarming. When Norway accepted the Marshall Plan in April 1948, increased electricity production for industrial needs was defined as the country's main contribution to European postwar reconstruction.[7] Thus, when Vogt as head of the Norwegian Water Resources and Electricity Works asked if the climate was changing, and if this would be possible to forecast, his request was taken very seriously.[8] In line with influential contemporary climatologists such as Helmut Landsberg, Vogt understood climate as an inexhaustible natural resource.[9] Climate was what controlled the rainfall needed to produce hydropower, and climate prediction was key to managing this vital national resource.

The Academy established a Committee on Weather and Climate Variation, which worked in a multidisciplinary rather than an interdisciplinary way. The group consisted of three meteorologists (Theodor Hesselberg, Einar Høiland, Halvor Solberg), two botanists (Ove Arbo Høeg, Knut Fægri), an expert on oceanography (Harald Ulrik Sverdrup), an

[2] Cerys A. Jones, S. J. Davies and N. Macdonald. "Examining the social consequences of extreme weather: the outcomes of the 1946/1947 winter in upland Wales, UK". *Climatic Change*. 2012: 35-53; Hall, Alexander. *Risk, Blame, and Expertise: The Meteorological Office and extreme weather in post-war Britain*. PhD-thesis, University of Manchester. 2012: 63-73; Robertson, Alex J. *The Bleak Midwinter 1947*. Manchester University Press. 1987; Roberts, Cedric. "The Winter of 1947 in Halesowen, West Midlands". *Weather*. Vol. 58, 2003: 113-119; Kearns, Kevin C. *Ireland's Arctic Siege, The Big Freeze of 1947*. Gill & MacMillan. 2011. For a contemporary account from Britain, see: Manley, G. "Looking back at last winter (a) February 1947: its place in meteorological history". *Weather*. Vol. 2, No. 9. 1947: 267–272.

[3] "Lite håp om regn" ['Little hope for rain']. *Verdens Gang*. 19.8.1947: 1.

[4] Bjørbæk, Gustav. *Norsk vær i 110 år: Temperatur, nedbør, værrekorder.* Damm Forlag. 2003: 143.

[5] "Avlingene ved Landbrukshøgskolen 50 prosent av et normalår" ['Crops at the College of Agriculture 50 percent of a normal year']. *Verdens Gang*. 1.9.1947: 2.

[6] "Ikke nedslakting på slump" ['Not slaughter at random']. *Verdens Gang.* 30.8.1947: 2.

[7] Skjold, Dag Ove. *Statens Kraft 1947-1965. For velferd og industri.* Universitetsforlaget. 2006.

[8] Letter from Vogt. *Beretning.* 1950: 2-3. The Academy was chosen because they "have members from all camps of science: meteorologists, physicists, botanists, geologists etc."

[9] Landsberg, Helmut. "Climate as a Natural Resource". *The Scientific Monthly. Vol.* 63, No. 4. 1946: 293 – 298. See also Vladimir Janković's paper in this issue. For more on Landsberg's later attempts at establishing a 'scientific middle ground' in environmental debates in the US, see: Henderson, Gabriel. *Raising the alarm: The cultural origins of climate 'denialism' in America, 1970-1988.* PhD Dissertation, Michigan State University. 2014.

expert on glaciers (geographer Werner Werenskiold), an astrophysicist (Svein Rosseland), a historian (Johan Schreiner), and a representative from the Water Resources Service (Halfdan Klæboe).[10] Representatives from the different disciplines worked side by side on independent projects, but outside the board meetings that took place at the state Meteorological Office, there was no collaboration. The reports on their progress consisted of minutes of meetings and individual papers, but there were no final report that summarized the findings.

The result was a plethora of studies: The botanists conducted tree-ring dating (Dendrochronology) and pollen analysis in marshes to map the climate fluctuations in the recent past.[11] The meteorologists used past weather observations to map the geographical patterns of the changing climate.[12] The oceanographer examined the sea-ice in the Arctic Ocean, and the glaciologist mapped the retreat of the mountain glaciers as proxies for the impact of these variations.[13] The astrophysicist began investigating the correlation between climate and sunspot cycles, while the representative from the Water Resources Service did a statistical mapping of the fluctuations in runoff.[14] Finally, the historian had a student analyze river flows using historical records from timber mills.[15]

While the studies documented that the climate had fluctuated, the search for patterns in the climatological records was far from useful for making predictions. Regardless of the method used, the variations were greater than the trends. The pollen analysis, for instance, suggested that climate changed in 600-year cycles, give or take a few decades. The tree-ring dating suggested 33-year patterns, correlating with the 11-year sunspot cycles, but again reality did not fully align with the statistical trends. Similarly, the meteorologists showed that a "wet" year could have two to three times more downpour than a "dry" year, and that even in "normal" years the annual fluctuation in river flows could be 10 percent or even greater.[16]

The most useful findings for the hydroelectric producers came from the meteorologists, who could rely on previously published research. In the 1930s, inspired by reports that the season for ice-free harbors on Spitsbergen (Svalbard) had increased from 120 to 200 days, the head of the Norwegian Meteorological Institute, Theodor

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[10] *Beretning.* 1950: 4. The group was financed by the Norwegian Hydropower Association ['Reguleringsforeningens Landssammenslutning'], with modest contributions from power-intensive industries.

[11] Fægri, Knut. "Pollenalanysens anvendelse for undersökelse av sykliske klimavariasjoner" ['Using pollen analysis to investigate cyclic variations']; Höeg, Ove Arbo. "Dendrokronologi og klimaendringer" ['Dendrochronology and climate variations']. *Beretning.* 1950: Attachments 1 and 4.

[12] Hesselberg, Theodor. "Hva de meteorologiske observasjoner viser om klimavariasjonene i Norge" ['What the meteorological observations show regarding climate variations in Norway']. *Rapport fra Utvalget for vær og klimavariasjoner*. Blindern. December 2, 1948: 22.

[13] Sverdrup, Harald Ulrik. "Oseanografiske observasjoner som antyder en klimaendring" ['Oceanographic observations which suggest climate change']; Werenskiold, Werner. "Bremålinger i Jotunheimen" ['Glacier measurements in Jotunheimen']. *Beretning.* 1950: Attachments 7 and 8; Fægri, Knut. "On the variations of Western Norwegian glaciers during the last 200 years". *Procès-verbause des séances de l'Assemblée Générale d'Oslo de l'Union Géodesique et Géophysique Internationale.* 1948: 293-303.

[14] Rosseland, Svein. "Solen som variabel stjerne. – Solaktivitetens virkning på jorden" ['The sun as a fluctuating star. – The effect of solar activities on earth']; Klæboe, Halfdan. "Fluctuations in Run-off". *Beretning.* 1950: Attachment 5 and 6.

[15] Authén, Grethe. "Elvenes vannføring på 1700-tallet, belyst ved fogderegnskapenes sagmannstall" ['River levels in the 1700s, illustrated by shire saw-records']. *Beretning.* 1950: 72.

[16] Hesselberg 1948: 22, ref. note 12.

Hesselberg, and the head of the Section for Climate, Bernt Johannes Birkeland, had begun examining the secular variations in the Norwegian climate.[17] When weather forecasting was banned during the five years of Nazi occupation, the meteorologists stepped up their efforts on time-consuming climatological research.[18] In this research, climate was understood as a regional and measurable phenomenon consisting of average temperature, humidity, precipitation, wind, and air pressure.

Based on around 1.8 million observations and accompanied by over 200 pages of tables, all calculated by hand, Hesselberg and Birkeland concluded that the climate in Norway had changed more in the past fifty years than it had the previous two hundred.[19] The average temperature had increased by 0.6 degrees centigrade from 1911 to 1940. The increase was greater in the north than in the south, and the change was stronger in winter and spring than in summer and fall. The most extreme changes had taken place in Karasjok, Kautokeino and Sør-Varanger in the far north of the country, where the average temperatures in February had increased by more than four degrees centigrade. Further, rainfall had increased by up to twenty percent in the south-eastern part of Norway, while north-western Norway had become up to fifteen percent drier. Accompanying this, the frequency of winds from the southeast had increased by 25 percent, while winds from the northwest had decreased by 20 percent. This meant, they explained, that warmer and more humid winds from the south had brought more precipitation, and with a mountain range separating east from west, north-western parts of Norway were left in a relative rain-shadow.

According to Hesselberg, the geographical pattern had clear practical implications: producers of hydropower in different parts of the country needed to collaborate. When it rained on the eastern side of the mountains, the production of electricity should be increased and "exported" to the west – and vice versa.[20] While useful, this was not really what Vogt had in mind when he had asked for long-term forecasts for years or decades.

Hesselberg and Birkeland's research was extremely empirical, and unlike climatologists of the same generation, they were not interested in stretching the study back to before the official records began in 1866.[21] In addition, contrary to concurrent

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[17] Secular variation was defined as climate change over periods of a hundred years or more.

[18] Barlaup, Asbjørn. *Det norske meteorologiske institutt 1866-1966*. Fabritius & Sønner. Oslo. 1966: 64-70.

[19] Hesselberg, Th. and B. J. Birkeland. "Säkulare Schwankungen des Klimas von Norwegen. Teil 1. Die Lufttemperatur" ['Secular variations in the Norwegian Climate. Part 1. The air temperature']. *Geofysiske Publikasjoner*. Vol. XIV, No. 4. 1940; Hesselberg, Th. and B. J. Birkeland. "Säkulare Schwankungen des Klimas von Norwegen. Teil 2. Die Niederschlag" ['Secular variations in the Norwegian Climate. Part 2. Precipitation']. *Geofysiske Publikasjoner*. Vol. XIV, No. 5. 1941; Hesselberg, Th. and B. J. Birkeland. "Säkulare Schwankungen des Klimas von Norwegen. Teil 3. Luftdruck und Wind" ['Secular variations in the Norwegian Climate. Part 3. Air pressure and wind']. *Geofysiske Publikasjoner*. Vol. XIV, No. 5. 1943; Hesselberg, Th. and B. J. Birkeland. "Säkulare Schwankungen des Klimas von Norwegen. Teil 4. Die Feuchtigkeit" ['Secular variations in the Norwegian Climate. Part 4. Humidity']. *Geofysiske Publikasjoner*. Vol. XV, No. 2. 1944. The temperatures previous to the official Norwegian records began in 1866 were gathered from Stockholm, Copenhagen, Edinburgh and Stykkisholm on Iceland. (Hesselberg and Birkeland 1940: 26-27)

[20] Hesselberg, Theodor. "Memorandum til Utvalget for vær- og klimavariasjoner" ['Memorandum to the Committee for weather and climate variations']. November 1948. *Beretning.* 1950: 41.

[21] See for instance: Britton, C. E. "A Meteorological Chronology to A. D. 1450." *Geophysical Memoirs*. No. 70. Meteorological Office, London. 1937.

research of climatologist Gordon Manley in the UK or glaciologist Hans Ahlmann in Sweden, there were no references to amateur observations, no real interest in glaciers and snowfall, and no links between climate and culture.[22] Although the findings would have supported Ahlmann's theory of polar warming,[23] he was merely mentioned in the passing as one of several researchers having pointed out that climate varied with time.[24] And while Manley was generally skeptical of identifying patterns or trends from his long-term records,[25] this was exactly what Hesselberg and Birkeland set out to do. Finally, even though the Norwegian researchers argued that their climatological findings were linked to atmospheric circulation, they made no mention of Tor Bergeron's dynamic climatology.[26] In general, Hesselberg and Birkeland did not engage in ongoing debates on climate variations elsewhere: in line with their empiricist approach, the observations, calculated and put into tables and graphs, should speak for themselves.

A separate strategy that the Norwegian meteorologists pursued was to use records from the growing international network of radiosonde observations. After discussing the matter with several experts abroad, a group of meteorologists in Oslo requested upper air-observations from 33 countries in the northern hemisphere.[27] The dual purpose of the study was to investigate the abnormal spring and summer of 1947, and to examine if the observations could be used in extending the weather forecasts. However, when it turned out that the dataset from December 1948 was the most comprehensive, the ambition of investigating the drought in 1947 was abandoned. Increasingly, what mattered to the meteorologists was extending the weather forecasts. In December 1949, at the fifth and final meeting of the committee, meteorologist Einar Høiland suggested that instead of working out predictions for years or decades, «the only rational way forward» was incremental steps, starting with extending forecasts from 24 to 72 hours.[28] He failed to mention that experiments in extended forecasts had begun more than a decade earlier, independent of the Committee's work,[29] but the representative from the Water Works agreed that three-day forecasts would be useful.

[22] Endfield, Georgina, Lucy Veale and Alexander Hall. "Gordon Valentine Manley and his contribution to the study of climate change: a review of his life and work". *WIREs Climate Change*. Vol. 6. 2015: 287–299; Endfield, Georgina. "Reculturing and Particularizing Climate Discourses: Weather, Identity, and the Work of Gordon Manley". *Osiris*. Vol. 26, No. 1, Klima. 2011: 142-162. See also Alexander Hall's paper in this issue.

[23] Sörlin, Sverker. "The Anxieties of a Science Diplomat: Field Coproduction of Climate Knowledge and the Rise and Fall of Hans Ahlmann's "Polar Warming"". *Osiris*. Vol. 26, No. 1, Klima. 2011: 66-88, p. 88.

[24] Hesselberg and Birkeland 1940: 7.

[25] Endfield, Veale and Hall. 2015: 292.

[26] For more on Bergeron's dynamic climatology, see Jim Fleming and Philipp Lehmann's papers in this issue.

[27] Through the Norwegian meteorologist Jørgen Holmboe at UCLA, they got in touch with Jerome Namias, head of the Extended Forecasting Section at the U.S. Weather Bureau in Washington, and arranged for him to visit Oslo to demonstrate the American methods for 5- and 30-day forecasts. Two meteorologists were sent to visit Carl-Gustaf Rossby in Stockholm, and Arnt Eliassen filed a report on the forecasting methods used at the University in Chicago. They also read up on research being done elsewhere in Europe and in the Soviet Union. Høiland, Einar. "Rapport fra Dr. Høiland". *Beretning.* 1950: 46-48.

[28] Report from meeting, Thursday December 1, 1949. *Beretning.* 1950: 8.

[29] The seasonal four-day forecasts for the fisheries in the North Sea, based on surface observations, were broadcasted by radio three times a week. Petterssen, Sverre. *Kuling fra nord – en værvarslers erindringer.* 1974: 199. An English translation of Petterssen's autobiography was published by the American Meteorological Society under the title *Weathering the Storm*, edited by James R. Fleming, in 2001. See

The committee finally agreed to contact the newly established Norwegian Council for Scientific and Industrial Research, to secure more reliable funding. A group consisting of meteorologists Hesselberg and Høiland and astrophysicist Rosseland, all former Bjerknes-acolytes,[30] wrote a proposal to turn the Committee into an Institute for Weather- and Climate Research: "The purpose of this inquiry is primarily to give the committee a more permanent character by the indicated name-change, while the activities in the beginning will continue along current lines."[31] In the application, emphasis was on improving long-term weather forecasting following the line of research developed by the Bergen school of meteorology, while the prospect of swift progress in climate prediction was downplayed. The main argument was the economic usefulness of the research and a desire to reinforce an already established collaboration with the Norwegian Meteorological Institute, the Norwegian Polar Institute and the Water Resources and Electricity Works. The application also highlighted that similar research into long-term forecasting, utilizing three-dimensional synoptic- and radiosonde observations from the northern hemisphere, was going on at the Extended Forecasting Section at the U.S. Weather Bureau in Washington D.C, headed by Jerome Namias, at the University of Chicago and at the Stockholm University College under the leadership of Carl-Gustaf Rossby, and at The Forecast Research Division in Dunstable, England, headed by Reginald Sutcliffe.

There were several reasons why the committee received the funding it asked for. In addition to being vital for the postwar reconstruction and already having secured annual contributions from the Norwegian Academy of Science and Letters, historian Kim Gunnar Helsvig has shown that two of the three experts who evaluated the application had themselves been members of the multidisciplinary taskforce.[32] Also, it probably did not hurt that the year before requesting climate prediction Fredrik Vogt had been instrumental in instituting the Norwegian Research Councils, where Committee member Svein Rosseland was deputy head.[33] The following decade, Høiland's annual applications

also: Fleming, James R. "Sverre Petterssen, the Bergen school, and the Forecasts for D-day". *History of Meteorology.* Vol. 1, 2004: 75-83.

[30] Hesselberg had started his career as an assistant to Vilhelm Bjerknes in Kristiania in 1908-12, and joined him in Leipzig in 1912-15, before being appointed director of the Norwegian Meteorological Institute in 1915. (Sverdrup, Harald Ulrik. "Theodor Hesselberg". *Norsk Biografisk Leksikon.* 1934.) Rosseland had been an assistant for Bjerknes in Bergen from 1919. However, when it turned out his proficiency for drawing weather maps was severely limited, he was sent as an assistant to Niels Bohr in Copenhagen instead. (Vaagen, Jan S. "Norske fysikere. Niels Bohr og hans institut." *Niels Bohr 100 år. Vitenskapsmann og Verdensborger.* Vitenskapsteoretisk forum, Universitetet i Bergen, Skriftserien nr. 3. 1985: 71). Einar Høiland began his career as Bjerknes' last Carnegie-assistant in 1935. (Godske, Carl Ludvig et. al. "In memory of Vilhelm Bjerknes on the 100th Anniversary of his Birth". *Geofysiske Publikasjoner*. Vol. XXIV. 1962: 22.)

[31] "Søknad D-106." [Application to Norges Teknisk-Naturvitenskapelige Forskningsråd]. RA/S-2939/D/Db/Dbd/Ddbd/L0763/0004. Riksarkivet ['Norwegian State Archive'], Oslo. 1950: 4.

[32] Helsvig, Kim Gunnar. *Elitisme på norsk: Det Norske Videnskaps-Akademi 1945-2007.* Novus/DNVA, Oslo. 2007: 81. The three members of the Committee for Geophysics were Halvor Solberg, Theodor Hesselberg and professor of physics, Lars Vegard.

[33] Slagstad, Rune. *De nasjonale strateger.* Pax, Oslo. 1998: 297; Devik, Olaf. *N.T.H. femti år: Norges tekniske høgskoles virksomhet 1910-1960*. Oslo. 1960: 185-187; Røberg, Ole Anders. «*Vitenskap i krig og fred.» Astrofysikeren Svein Rosseland i norsk forskningspolitikk 1945-1965.* Garduate thesis in History, University of Oslo. 2000: 51-55; Barlaup, Asbjørn. *NTNF – Ti-års beretning 1946-1956.* Norges teknisk-naturvitenskapelige forskningsråd. 1956: 24-26.

for "theoretical and empirical research with aim to analyze the variations in weather and climate, and identify their causes", summarizing the past years' activities at the Institute, were all marked with an expectation of receiving similar grants for "several years to come".[34]

Staring at the sun

The Institute for Weather and Climate Research was located on the second floor at the Institute for Theoretical Astrophysics at the University of Oslo, with funding for one senior scientist, two junior researchers, an assistant and a secretary. It was headed by Einar Høiland, who had been the secretary of the preceding Committee. The Institute arranged seminars, had international guests, and collaborated on research projects. In addition to inviting colleagues from the Institute of Meteorology, Høiland offered research positions to promising students who shared his interest in theoretical hydrodynamics.[35] Of fourteen researchers affiliated with the institute, eight focused on hydrodynamics (Per Martin Breistein, Arne Foldvik, Yngvar Gotaas, Einar Høiland, Jack Nordø, Eyvind Riis, Sigurd Jahr Smebye, Kristian Trægde), three on theoretical meteorology (Arnt Eliassen, Ragnar Fjørtoft, Kåre Pedersen), two on cloud physics (Egil Hesstvedt, Marius Todsen), and one on mathematics (Enok Palm).

Apart from a failed cloud seeding experiment,[36] the research at the Institute was highly theoretical: 38 of 50 publications concerned hydrodynamics, particularly expressing weather phenomena such as the impact of topography, gravity, friction and the dynamic interactions between different layers of the atmosphere in quasi-geostrophic equations. Eight reports focused on cloud physics, particularly the formation of mother of pearl clouds,[37] droplets and thunderstorms. Only three studies had any relation to climate. One was a literary review of Grosswetter-studies,[38] the two others were statistical investigations of the relations between solar activity and terrestrial climate.[39]

The reorganization of the Norwegian Universities for mass education, which translated into expanding the academic staff and a corresponding change in research

[34] RA/S-2939/D/Db/Dbd/Ddbd/L0763/0004; RA/S-2939/D/Dbd/Ddbd/L0764/0001.

[35] Interview with Arne Foldvik, Bergen, 10.10.2014.

[36] Unsigned. "Report on a Cloud Seeding Experiment". *Reports from the Institute for Weather and Climate Research.* No. 6, 1956.

[37] Mother of pearl clouds are high altitude cloud formations (15-25.000 meters) that develop in Polar Regions, today referred to as Polar stratospheric clouds. Through investigating this rare (and beautiful) weather phenomenon, the goal was to gain insight into atmospheric conditions, especially humidity and motion, at higher altitudes that could not be acquired through the distributed radiosonde network.

[38] Nordø, Jack. "Oversikt over en del nyere 'Grosswetter'-undersøkelser" ['Overview over some newer Grosswetter-research']. *Reports from the Institute for Weather and Climate Research.* Oversiktsartikkel No. 1, 1952. Grosswetter-studies, literally large-scale weather, are studies of mean pressure distribution over time.

[39] Nordø, Jack. "A Statistical Discussion of a Possible Connection between Solar Activity and Sea-Level Pressure"; Nordø, Jack. "A Comparison of Secular Changes in Terrestrial Climate and Sunspot Activity". *Reports from the Institute for Weather and Climate Research*. No. 5, 1955. See also: Nordø, Jack. "Solaktiviteten og dens innflytelse på atmosfæren" ['Solar activities and its influence on the atmosphere']. *Naturen*. 1954: 192.

funding, was the main reason why the Institute was closed in 1960.[40] In their announcement, the research council stressed that this was not a critique of the research, but in line with their general policy of expanding the universities rather than funding independent institutes: "It is exclusively the organizational terms we found counterproductive in the long term."[41] In return, they suggested channeling a similar amount of funds, approximately 70.000 NOK per year, into permanent positions at the Universities, so that the research could continue there.

As historian Kristine Harper and others have pointed out, the 1950s saw an increased interest in numerical weather forecasting using computers, especially in the wake of the first computer generated weather forecast at the Institute for Advanced Studies at Princeton: "Meteorologists from academic, the Weather Bureau, and the military - in Princeton, Stockholm, Chicago, New York, Cambridge, and Washington - were busy trying to develop a workable theory of atmospheric motion that could then be programmed into von Neumann's new machine."[42] Both Arnt Eliassen and Ragnar Fjørtoft moved from being important members of the Princeton project to doing research at the Institute for Weather and Climate Research in Oslo.[43] However, the Institute did not have access to computers, and instead of numerical weather prediction, their approach followed in the footsteps of the Bergen school of meteorology. That Vilhelm Bjerknes until his death in 1951 had his office at the same building as the Institute, and that the leading investigators had all started their careers as Carnegie-assistants to Bjerknes, probably influenced the choice of direction. However, the legacy would eventually turn out to be a disadvantage.

While the computer models went from extreme simplification to increased model complexity, Høiland's team started at the other end. Ideally all complexities should be included in the equations. However, the fact that they followed a different tradition than the numerical and published most research in technical reports instead of in journals with wider readership, the research was of little relevance to the wider scientific community and to the new approach to theoretical meteorology that took the computer models as their starting point. It would be decades before computers were powerful enough for the equations developed at the Institute to be put into practice in numerical weather forecasting, and by then the technical reports were mostly forgotten.

Another distinctive feature of the Norwegian weather research in this period was that there were no links between meteorology and atmospheric chemistry. At Carl Gustaf Rossby's International Meteorological Institute in Stockholm, which was inaugurated at more or less the same time as Høiland's institute in Oslo, research into atmospheric chemistry went hand in hand with numerical weather prediction and studies into climate variations.[44] Interested mainly in hydrodynamics, the researchers in Norway saw

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[40] Ore, Aadne. "Det matematisk-naturvitenskapelige fakultet". *Universitetet i Oslo 1911-1961*, Bd. 2. Universitetsforlaget. 1961: 95-98; Helsvig 2007: 82.

[41] Letter from The Norwegian Council for Scientific and Industrial Research to Einar Høiland, signed by Georg Hygen, dated Oslo, February 15, 1960. RA/S-2939/D/Db/Dbd/Ddbd/L0763/0004.

[42] Harper, Kristine C. *Weather by the numbers: the genesis of modern meteorology*. MIT Press. 2008: 150.

[43] Harper, Kristine C. "The Scandinavian Tag-Team: Providers of atmospheric reality to numerical weather prediction efforts in the United States (1948-1955)". *History of Meteorology.* Vol. 1, 2004: 84-91.

[44] Rossby, Carl Gustaf and H. Egnér. "On Chemical Climate and Its Variation with the Atmospheric Circulation Pattern". *Tellus*. Vol. 7, No. 1. 1955: 118-133; Bohn, Maria. "Concentrating on CO2: The Scandinavian and Arctic Measurements". *Osiris*. Vol. 26, No. 1, Klima. 2011: 165-179.

temperature, pressure and humidity as what characterized differences in the air, not its chemical composition. Atmospheric chemistry in the period was a Swedish, and partly Finnish, endeavor.[45] With the exception of a short popular text on a possible link between acid rain and fish death, published in 1959,[46] atmospheric chemistry was first introduced to Norwegian meteorological research in the early 1970s when the newly established Norwegian Institute for Air Research led an OECD research program into air pollution dispersion.[47]

Some of the reasons for prioritizing hydrodynamics rather than climate variations can be found in a public lecture held by Høiland at the annual meeting of the Research Council in March 1952 entitled "Climate fluctuations and possible causes".[48] Høiland's argument was that climate had changed for the better, meaning it was warmer, that this was caused by changes in the energy from the sun, and that this was likely a short-term fluctuation. His presentation reflected the general view among the meteorologists at the time: the sun was the 'engine' or 'power source' for the atmosphere, and was, therefore, the cause for climate variations. This theory was famously put forward by James Croll in 1875.[49] While not supporting the specifics of Croll's theory, Norwegian oceanographers such as Bjørn Helland-Hansen, Harald Urik Sverdrup and Fridtjof Nansen had in the first decade of the 20th century argued that the key to climate variations on earth was the sun.[50]

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[45] Bohn 2011. For more on early climate modelling, see: Heymann, Matthias. "Constructing Evidence and Trust: How Did Climate Scientists' Confidence in Their Models and Simulations Emerge?". In: Hastrup, Kirsten and Martin Skrydstrup (eds). *The Social Life of Climate Change Models. Anticipating Nature*. Routledge Studies in Anthropology. 2013: 203-224.

[46] Dannevig, Alf. "Nedbørens innflytelse på vassdragenes surhet og på fiskebestanden" ['The influence of percipitation on acidities in rivers and on fish populations']. *Jeger og Fisker.* No. 3. 1959: 116-118.

[47] OECD. *The OECD Programme on Long Range Transport of Air Pollutants: Measurements and findings.* Paris. 1977. The project confirmed that pollution from sulfur dioxide was transferred between European countries, and that two third of pollution in Scandinavia originated from outside sources. (Rothschild, Rachel. "Burning Rain. The Long-Range Transboundary Air Pollution Project." In: Fleming, Jim, and Ann Johnson, eds. *Toxic Airs.* Pittsburgh. 2014: 181-207). The report led to the establishment of the Convention on Long-range Transboundary Air Pollution, the first international legally binding instrument to deal with problems of air pollution on a broad regional basis. The convention was signed in 1979 and entered into force four years later. (Gillespie, Alexander. *Climate Change, Ozone Depletion and Air Pollution. Legal Commentaries with Policy and Science Considerations.* Brill, Leiden. 2006; Underdal, Arild and Kenneth Hanf (red). *International Environmental Agreements and Domestic Policies. The case of acid rain.* Ashgate. 2000, particularly chapters 3, 4 and 11.)

[48] Høiland, Einar. "Klimasvingninger og mulige årsaker til dem. Foredrag holdt ved årsmøtet 19. mars 1952 i Norges Allmennvitenskapelige Forskningsråd." ['Climate fluctuations and possible causes. Lecture held at the annual meeting of the Norwegian Research Council for Science and the Humanities, March 19, 1952']. *Naturen*. 1953.

[49] Croll, James. *Climate and Time in their Geological Relations. A Theory of Secular Changes of the Earth's Climate*. 1875. For more on Croll, see Gunnar Ellingsens paper in this issue.

[50] Helland-Hansen, Bjørn and Fridtjof Nansen. "Temperaturschwankungen des Nord-Atlantischen Ozeans und in der Atmosphäre" ['Temperature fluctuations in the North Atlantic Ocean and in the atmosphere']. *Vitenskapsselskapets Skrifter, No. 9.* Kristiania, 1917; Sverdrup, H. U. "Die Beziehungen der elfjährigen Klimaschwankungen zur Sonnentätigkeit" ['The relations between 11-year climate variations and solar activities']. *Annalen der Hydrographie und maritime Meteorologie*, Berlin. 1918; Helland-Hansen, Bjørn and Fridtjof Nansen. "Temperature Variations in the North Atlantic Ocean and in the Atmosphere. Introductory study on the Cause of Climatological Variations". *Smithsonian Miscellaneous Collections.* Vol. 70, No. 4. 1920; Ellingsen, Gunnar. *Varme havstrømmer og kald krig: "Bergensstrømmåleren" og vitenskapen om havstrømmer fra 1870-årene til 1960-årene.* ['Warm ocean currents and cold war: "the Bergen current-meter" and the science of ocean currents from the 1870s to the 1960s']. PhD-Dissertation,

The position was supported by leading astronomers at the time,[51] and in Norway the importance of the sun was probably reinforced by the Rockefeller Foundation-financed solar observatory at Harestua outside Oslo, which opened in 1954.[52]

The debate at the time was not whether climate variations were caused by the sun, but if the warmer climate was due to an increase or a decrease in the solar energy. From the 1930s, the British meteorologist George Clarke Simpson had argued that more solar energy caused more clouds, more snow, growing glaciers and that this eventually would lead to more energy being reflected.[53] Therefore, the observed heating could just as likely herald the start of a new ice age. This fit well with another authoritative hypothesis at the time, the American meteorologist Hurd Curtis Willet's theory of cyclic variations, which predicted that the average temperatures would start dropping significantly in the late 1950s.[54] Hesselberg and Birkeland's update to their own study, published in 1956, pointed in the same direction: in the 1940s the rise in temperatures had slowed down compared to the preceding decennium.[55]

The real worry of the time was not that the observed warming would continue indefinitely, but that the climate would inevitably turn for the worse and that humanity would face a new Ice Age. The research conducted at the Institute should, therefore, focus on understanding the mechanisms of the atmosphere so that the coming Ice Age could be stopped. Høiland argued:

> "Has climatology reached a complete understanding of what lies behind climate change, the mechanisms that are at work? And even more important, has it found ways to intervene and control this mechanism, so that the ice can be stopped?"[56]

Framing the problem of climate variations as a matter of developing methods for avoiding the coming Ice Age made studying the dynamics of the atmosphere more vital

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University of Bergen. 2013: 100-101. In an interview with a daily newspaper in 1958, Jack Bjerknes argued that the relation between solar activity and climate variation was "inescapable". "Vil polarisen forsvinne helt?" ['Will the polar ice cap disappear completely?]'. *Verdens Gang*. 8.5.1958.

[51] See for instance: Hoyle, Fred. "External sources of climatic variation". *Quarterly Journal of Royal Meteorological Society.* Vol. 75, 1949: 161-163.

[52] Brahde, Rolf. "Solobservatoriet på Harestua" ['The solar observatory at Harestua']. 1998. [https://www.ub.uio.no/fag/naturvitenskap-teknologi/astro/historiske-samlinger/brahde_solobservatoriet_1998.pdf]

[53] Simpson, G. C. "Further studies in terrestrial radiation". *Memoirs of the Royal Meteorological Society*. Vol 3. 1930: 1-26; Simpson, G. C. "World climate during the Quaternary Period". *Quarterly Journal of the Royal Meteorological Society*. Vol. 60. 1934: 425-478.

[54] Willett, H. C. "Long-period fluctuations of the general circulation of the atmosphere". *Journal of Meteorology.* Vol. 6, No. 5. 1949; Willett, H. C. "Solar variability as a factor in the fluctuations of climate during geological time". *Geografiske Annaler.* 1949. See also: Godske, C. L. *Hvordan blir været? Meteorologi for alle*. ['What will the weather be? Meteorology for everyone']. J. W. Cappelens Forlag. Oslo. 1956: 189.

[55] Hesselberg, Th. and B. J. Birkeland. "The continuation of the secular variations of the climate of Norway 1940-50." *Geofysiske Publikasjoner.* Vol. XV, No. 5. 1956.

[56] Høiland 1953: 43. On the relationship between climatology and Bergen school hydrodynamics, see Lehmann's paper in this issue.

than investigating climate patterns in the past. According to Høiland, it was through knowing the mechanisms in the atmosphere that humanity could stage an intervention.[57]

A matter of prestige

Høiland's emphasis on mechanisms rather than geographical or temporal patterns in the climatic record reflects another trait shared by the meteorological research community in the 1950s: In the shadow of the Bergen school, climate studies had low prestige and was often portrayed as a second-rate science. According to meteorological textbooks used from the 1940s, all science matured through distinct phases: first, speculation was replaced by observation. Second, observations were systematized and one could start looking for patterns. In the third phase, the mechanisms behind the phenomenon were uncovered and science became predictive, which was what the Bergen school of meteorology had brought to the table.[58] In popular books on meteorology published in Norway in the 1950s, a fourth phase was added, "applied science", which meant using the mechanisms to stage interventions to control the weather and possibly the climate of the future.[59] According to this positivist narrative of linear progress, studying the climate through looking for patterns in past observations was merely second phase science. Only research and forecasting based on physics and hydrodynamics was truly predictive, since this was the only part of meteorology that had uncovered underlying mechanisms. To Høiland, climate research was merely statistical tinkering, a science of the past using methods of the past.

The low prestige of climatology in the period was also an international phenomenon. In his first public lecture as President for the Commission on Climatology in the World Meteorological Organization (WMO) in 1953, Charles Warren Thornthwaite stressed: "I hope that we may soon rise up from our inferior position in the hierarchy of meteorology."[60] When climatology received attention in the *WMO Bulletin* in the 1950s, it was only to repeat the mantra that the specialization should have higher ambitions than providing statistical descriptions of the past.[61] When the new president of

[57] For more on the history of weather control, see: Fleming, James. *Fixing the Sky: The Checkered History of Weather and Climate Control.* Columbia University Press. 2010.

[58] Petterssen, Sverre. *Introduction to Meteorology.* McGraw-Hill Book Company, Inc. New York and London. 1941: 217-224.

[59] Godske 1956: 22.

[60] Thornthwaite, C. W. "A Charter for Climatology. Presidential address at the First Session of the Commission for Climatology, Washington, March 1953". *WMO Bulletin.* April 1953: 46.

[61] "To many people at the present time, the content and scope of climatology is only this – the measuring, recording, and averaging of standard meteorological elements. I need not remind you that climatology when circumscribed in this way is sterile and unrewarding." Thornthwaite, C. W. "The Task Ahead In Climatology. Presidential Address at the Second Session of the Commission for Climatology, Washington, January 1957." *WMO Bulletin*. January 1957: 2-7, quote on p. 3; "Surely at this stage, it should not be necessary to convince meteorologists that the prospect of fundamental progress is negligible as long as climatology remains purely descriptive! The collected world weather charts, although they have the merit of containing in concise form a record of world weather from July 1957 to December 1958, will remain little more than a set of pretty picture books, unless the numerical data extracted from them be rationally analyzed." Schumann, T. E. W. "World Meteorology: Retrospect and Prospect". *WMO Bulletin*. January 1959: 29-35, quote on p. 34.

the Commission on Climatology, R. G. Veryard from the UK, in 1959 proposed establishing a permanent working group to study climate change, the reception was "somewhat divided".[62] Instead, after a suggestion by the Swedish meteorologist Carl Christian Wallén, the initiative resulted in a symposium on climatic changes held in Rome in 1961.[63]

Another reason the Institute for Weather and Climate research did not focus on climatology, was that the Meteorological Office already had its own Section for Climate.[64] In 1950, they employed two meteorologists and ten assistants.[65] Ten years later, the number of meteorologists had increased to four and the number of assistants to fourteen.[66] However, in a period when state funding for meteorology in Norway was increased by a factor of seven from the end of the War to 1960, this meant that the proportion of funds appropriated for climatology had decreased from 3.2 percent to below 2 percent.[67]

With the exception of the project headed by Hesselberg during the Second World War, the Section for Climate did very limited research. In addition to functioning as a public library for government agencies and insurance companies that wanted information on specific weather conditions in the past, the main activity was limited to making charts and tables for individual weather observation posts. To the Section for Climate, 'climate' was as Julius Hann had defined in the late 19th century: the average weather conditions at a single point on the planet.[68] Every year they published 5-day statistics from 34 stations and monthly statistics from 171 observation posts.[69] All calculations were done by hand, and by the end of 1956 they had a backlog of 598 months.[70]

According to meteorologist Sigurd Evjen, head of the Section for Climate from 1949 to 1956, the lack of research ambition was due to a lack of manpower. When Jerome Namias visited Oslo in 1949, he had explained that his section for long-term forecasting in the United States had sixty meteorologists, which was about the same as the total number of meteorologists in Norway: "We simply do not have the manpower to begin embarking upon the massive undertaking necessary for systematic predictions like in the United States", Evjen argued.[71] Ragnar Fjørtoft, who in 1955 succeeded Hesselberg

[62] "Climatology". *WMO Bulletin*. April 1959: 86.
[63] UNESCO. *Changes of climate. Proceedings of the Rome Symposium organized by UNESCO and the World Meteorological Organization*. Belgium. 1963.
[64] Interview with Arne Foldvik, Bergen, 10.10.2014.
[65] Det Norske Meteorologiske Institutt (Hereafter: DNMI), Boks 283, Budsjettforslag for Meteorologisk Institutt, 1945-1957. *Budsjettforslag for de meteorologiske institusjoner 1951-52*. ['Budget proposal for the meteorological institutions 1951-52']. Oslo, 31.08.1949.
[66] DNMI. *Årsberetning for de meteorologiske institusjoner i Norge for budsjettåret 1. juli 1959 til 31. desember 1960*. ['Annual report from the meteorological institutions in Norway for the budget year July 1 1959 to December 1, 1960']. Oslo. 1962.
[67] My calculation based on the accounts printed in the annual reports from the Meteorological Office.
[68] Hann, Julius. *Handbuch der Klimatologie. '[Handbook of climatology*']. Stuttgart. 1908. For more on the genesis of the empirical tradition, see: Nebeker, Frederik. *Calculating the Weather: Meteorology in the 20th Century.* Academic Press. 1995: Chapter 2.
[69] DNMI. *Norsk meteorologisk årbok*. Annual publication. 1945-1979.
[70] DNMI, Box 285. "Budsjettforslag MI, 1966-1970." *Budsjettforslag for De meteorologiske institusjoner for året 1970*. ['Budget proposal for the meteorological institutions for the year 1970']. February 8, 1969: Attachment 18.2: 1.
[71] "Langtidsvarslene fra USA - et gigantisk vær-eksperiment" ['The US long term forecasts - a gigantic weather experiment']. *Verdens Gang*. 9.7.1955.

as the head of the Norwegian Meteorological Institute, however, argued that the problem was in the methods and not the ambitions: "The reason why the Section for Climate is so inefficient is not primarily in the lack of staff, but in the methods and technical aids the section has at its disposal."[72] From 1957 the Section started using punch card machines, but the ambitions did not change: Climate research still consisted of organizing the records of the past and providing statistics for one and one place only.

After the computer FACIT 1 was inaugurated at the Meteorological Office in the summer of 1961, the capacity of the Section for Climate greatly expanded, and so did its activities.[73] Reflecting the emphasis on weather forecasting, between 70 and 80 percent of the computing time was spent on routinely producing computer generated upper air forecasts.[74] Still, while the climatologists used less than 15 percent of the computing time, this meant they could produce climate statistics on demand for road engineers, architects, agriculture, shipping industries, as well as electricity producers. Although climate prediction by now was off the table, statistics of temperatures in different parts of the county were useful for estimating power consumption, and a tool for managing the power supply. Producing climate statistics was not a new task: already in 1949 the climate section had been asked to identify the 10-day period in which the average weather conditions would be most advantageous for arranging the Winter Olympics in Oslo in 1952. With the computer, the calculations that in 1949 had taken months could now be completed in a matter of hours.[75]

Too many weather maps

Not all meteorologists agreed with prioritizing hydrodynamic research, and in the mid-1950s there was some debate regarding what *kind of* meteorological research to pursue. Most notably, meteorologist Petter Dannevig published a series of articles in the popular science magazine, *Naturen*, arguing that too much time was spent drawing weather maps.[76] At three forecasting stations and nine airports, surface maps were drawn manually up to eight times per day, in addition to two daily altitude maps. All this mapmaking, Dannevig argued, was turning meteorology into a handicraft, where science was reduced to a spare-time hobby with little to no impact on the practice of forecasting: "It might seem paradoxical, but at times the meteorologists seem not to see the weather due to all the weather maps."[77] Dannevig's remedy was to centralize the mapmaking and use the resources that were freed up on applying past climate observations in synoptic

[72] DNMI, Box 283. "Budsjettforslag for Meteorologisk Institutt, 1945-1957" ['Budget proposal for the Meteorological Office, 1947-57']. *Budsjettforslag for De meteorologiske institusjoner for* 1955/56. July 1, 1954: 4.

[73] DNMI. *Årsberetning for de meteorologiske institusjoner i Norge for 1961*. ['Annual report from the meteorological institutions in Norway for 1961']. Oslo. 1963.

[74] DNMI. *Annual Reports*, 1961-1971.

[75] Den Internasjonale Olympiske Komité. *Oslo 1952, VI Olympiske vinterleker/Olympic Winter Games*. Oslo 1952: 72; Godske 1956: 184-185.

[76] Dannevig, Petter. "Værvarslingen ved korsveien" ['Forecasting at a crossroads']. *Naturen.* No. 8. 1955; Dannevig, Petter. "Værvarslingsmetodene i søkelyset" ['Spotlight on the forecasting methods']. *Naturen*. No. 15. 1955; Dannevig, Petter. "Værvarslingen og vitenskapen" ['Forecasting and science']. *Naturen*. 1956.

[77] Dannevig 1955: 228.

statistics, documenting what "normally" happened in specific weather conditions. However, his suggestion was not followed up on: By 1962, the forecasting section at the Meteorological Office in Oslo, the largest one of three in the country, alone produced a minimum of 69 weather maps per day.[78] Regardless, Dannevig's bottom line echoed the mentality of most Norwegian postwar meteorologists: science or not, the pinnacle of meteorology was weather forecasts. If climate studies had a role to play, it was to improve the forecasts.

Synoptic statistics was not the only option for making climate observations useful for predictions. Inspired by the 30-day forecasts from the U.S. Weather Bureau, Evjen suggested combining climate statistics and persistence trends to make similar long-term forecasts for Norway. However, when put to the test, he concluded that in order to achieve 90 percent certainty, the confidence interval for average temperatures in the coming month had to be on plus/minus 3.8 degrees centigrade. This, he dryly noted, "would have severely limited practical application".[79] When Evjen died in November the following year, it seems no one was interested in continuing the project.[80]

Concluding remarks

This paper has posed a negative question: Why did the Norwegian meteorologists *not* pursue climate prediction in the first decades after the Second World War, despite funding and an explicit mandate to do so? At first glance, the answer seems simple: despite methods from several disciplines, climate variations were greater than the trends. The "signal to noise" problem, and the huge amounts of calculations which would have had to be made by hand, led to climate predictions being seen as too time-consuming and too complex to be feasible. However, more factors were involved.

The different actors had different understandings of 'climate'. For Vogt, climate was what controlled the rain that fueled the hydropower. For the Section for Climate, climate was the average weather conditions for a single observation point. For Hesselberg and Birkeland, climate was a regional phenomenon whose variations could be mapped over time. For Høiland, climate was the old-fashioned and sterile study of statistical averages. As head of the Institute for Weather and Climate Research, Høiland's view had a deep impact on the research interests of his institutions, and was reflected in the researchers he chose to recruit. In contrast, climatology in Norway lacked a 'champion' who could generate funding, organize recruitment and define what research to pursue.

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[78] The maps produced were six altitude maps, eight surface maps, six synoptic maps of Norway, seventeen prognostic maps, six analytical maps, and twenty-four weather maps to be telexed to airports. In addition, maps for 100mb and 200mb altitudes were produced most but not every day. Det Norske Meteorologiske Institutt. *Årsberetning for de meteorologiske institusjoner i Norge for budsjettåret 1962*. Oslo. 1964.

[79] Evjen Sigurd: "Statistisk varsling av middelverdier" ['Statistical forecasting of mean values']. *Naturen*. 1955: 181. See also: Evjen, Sigurd. "Statistiske stikkprøver som forundersøkelse for 30-dagers-varsling" ['Statistical sampling - a preliminary investigation for 30-day forecasting']. *Værtjeneste-memorandum*. No. 4. Det Norske Meteorologiske Institutt. Oslo. 1956.

[80] Evjen had studied climate prediction since the 1920s. Evjen, Sigurd. "Barometerschwingungen und langsichtige Prognosen" ['Barometric oscillations and long-term forecasting']. *Geofysiske Publikasjoner*. Vol IV, No. 1. 1927; Evjen, Sigurd. "Zur langfristigen Wettervorhersage" ['On long-term weather forecasting']. *Geofysiske Publikasjoner*. Vol. X, No. 3. 1935; Evjen, Sigurd. "Forecasting north-west gales in the Skager Rack (a synoptic-statistical study)". *Geofysiske Publikasjoner*. Vol. XVII, No. 5. 1949.

Further, climate studies had an inferior status among the meteorologists. It was seen as a science of a lower order focused on mapping the past rather than predicting the future based on already uncovered mechanisms. While this could have been seen as a call to arms, none were in a position to pick up the gauntlet. A similar lack of practical output did not stop the highly theoretical research into hydrodynamic equations at Høiland's institution. While the research did give new insights into the mechanics of the atmosphere, the results were essentially useless at the time. There were meteorologists who argued for more investment in climate studies, but they too maintained that the goal was to aid weather forecasting and not to develop climate prediction. Besides, the drought which had caused Vogt to contact the Norwegian Academy of Science and Letters did not return. The summer of 1947 was soon seen as an anomaly, not a warning of a lasting change.

Unlike climate prediction, forecasting was not just scientific and useful; it was also seen as attainable. When Fredrik Vogt contacted the Norwegian Academy of Science and Letters after the drought in 1947, he was simply asking too much: Climate prediction was understood to be impossible, and no one were willing to challenge this orthodoxy.

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